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Macrophytes as a heavy metal scavengers at MIDC effluent stream

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ABSTRACT

Environmental heavy metal pollution is mainly of anthropogenic. Heavy metals are ubiquitous environmental contaminants in industrialized societies. Most plants are able to accumulate heavy metals from water and soil. In present study investigation was made on *Croton tiglium* Linn., *Sonchus oleraceus* Linn., *Argemone mexicana* Linn., *Alocasia* (Schott) G. Don and *Cyperus* Linn. to evaluate the efficiency of phytoremediation. Results revealed that among the heavy metals studied viz. Cadmium, Mercury and Zinc efficient system for phytoremediation is *Croton tiglium* Linn. and *Sonchus oleraceus* Linn. Results also conclude that the order of sensitivity of heavy metals studied towards the five plants is Zinc > Cadmium > Mercury.

KEY WORDS

Heavy metals, Pollution, *Croton tiglium* Linn., Zinc, Phytoremediation.

INTRODUCTION

Environmental heavy metal pollution is mainly of anthropogenic origin and results from activities such as fossil fuels, vehicle emissions, industrial emissions, landfill leachates, fertilizers, sewage and municipal wastes (Nyangababo *et al*., 2005). Environmental pollution is a major threat to humanity. It is the result of industrialization, urbanization and growth in population.

In recent years, soil polluted by heavy metals has increased due to human activities and removal of such pollutants has also been of great concern (Agunbiade and Fawale, 2009). Direct discharge or wet and dry depositions of contaminants increase the concentration of trace elements in aquatic systems, thus resulting in their accumulation in sediments (Dunbabin and Bowmer, 1992; Sinicrope *et al*., 1992). Industrial effluent contains various metals viz. Ag, As, Au, Cd, Co, Cr, Cu, Hg, Ni, Pb, Pd, Pt, Mn, Rd, Sn, Th, U, Fe and Zn. Heavy metals have effects on human health and environmental setup due to their high occurrence as a contaminant, present in soluble form that are extremely toxic to biological systems, and on this basis classified as carcinogenic and mutagenic (Alloway, 1995; Diels *et al*., 2002). Moreover, the metals cannot be degraded to harmless products and hence persist in the environment indefinitely. Damage may cause adverse reactions in different organs and biological functions, including reproduction and birth defects (Malik, 2004).

The ability of plants to accumulate pollutants has received significant attention and given rise to a new technology called phytoremediation (Black, 1995). Most plants are able to accumulate heavy metals from water and soil, of which some are very important for their growth and development (Fe, Mn, Zn, Cu, Mo and Ni); but the excessive concentration of heavy metals may be toxic to most plants (Lasat, 1996). Biological methods solve drawbacks since they are easy to operate and do not produce secondary pollution and show higher efficiency at low metal concentrations (Chen *et al*., 2005).

The present paper reveals the findings of an ecofriendly remedy for removal of industrial contamination or say pollutants from the effluent discharge site, particularly heavy metals. The study site for this work was a MIDC industrial discharge site. The natural phanerogamic vegetation present at the discharged site is supposed to undergo a selection pressure to develop heavy metal resistivity and mainly works by process called phytoextraction. So, from the study site five macrophytes were selected and were studied *in-vitro* for metal absorption capacity. The results are very promising for heavy metal absorption and deduce the possibility of using this plant species for remediation of heavy metal contaminants from the effluent discharged site.

MATERIALS AND METHOD

Sampling Site

In the present work for study of phytoremediation of heavy metals an industrial polluted site was selected as the Maharashtra Industrial Development Corporation (MIDC) industries effluent discharged stream. The present sampling site is located on Gopal Nagar, Old bypass road, Amravati (Figure 1). The selection of the plant species for further work was based on their dominant presence on effluent discharged location. The plants which are present in the effluent stream or on the banks of the stream were collected for the laboratory work from different locations. So from the sampling site five different plants were selected and removed from the soil without breaking the roots.

Plant Materials

The plants which were collected from the sampling site for the present work are *Croton tiglium* Linn., *Sonchus oleraceus* Linn., *Argemone mexicana* Linn., *Alocasia* (Schott) G. Don and *Cyperus* Linn. The plants were cut into roots (along with primary and secondary roots), stem and leaves. For the single set of experiment one gram fresh weight of each plant viz., *Croton tiglium* Linn., *Sonchus oleraceus* Linn., *Argemone Mexicana* Linn., *Cyperus* Linn. containing roots, stem and leaves were taken. In case of the *Alocasia* (Schott) G. Don one gram fresh weight of Leaves, petiole and the tuber was taken to run the single set of experiment.

Treatment of Heavy Metals as Toxic Substances

Three different salts of toxic metalloids were taken to check the biosorption capacity of the macrophytes brought from the MIDC effluent stream. The heavy metal salts which were taken for the present work are Cadmium chloride [$CdCl_2$], Mercuric oxide [HgO] and Zinc nitrate [$Zn(NO_3)_2$]. The aqueous solution of these heavy metals was prepared in a concentration of 50 mgL^{-1}. For each set of experiment 20 ml of 50 mgL^{-1} of solution of each metal was taken and one gram freshly weighed plants material of each macrophyte was treated with the each heavy metals solution for 24 hours. Each such set of experiment was repeated thrice and each time after the period of treatment, the remaining solution was saved. Every time with the set of experiment control set was also run. The average data of each replicate was taken into consideration.

Estimation of Phytoremediation by macrophytes

Preparation of optimal sucrose medium for Pollen germination.

For this experimental case, various grades of percentage Sucrose solutions (10%, 20%, ..., 70%) containing 100 mgL^{-1} Boric acid were prepared for *in vitro* pollen germination of *Thevetia peruviana* (Pers.) K. Schum. From the percentage of pollen germination in various Sucrose solutions an optimal concentration of germination medium was noted, where pollen shows the maximum germination. Optimal Sucrose medium containing the Toxic substances

The contaminated solution left after the treatment of macrophytes for 24 hours was taken for the preparation of optimal sucrose medium containing 100 mgL^{-1} Boric acid. This culture medium was then used for the *in vitro* pollen germination of *Thevetia peruviana* (Pers.) K. Schum that was considered as tool for measuring the toxic metals in the macrophyte treated contaminated solution following method proposed by Gottardini *et al*., 2004.

RESULTS AND DISCUSSION

Optimal Sucrose culture medium for *in vitro* pollen germination

Of all the grades of culture medium 20% Sucrose medium shows the maximum pollen germination i.e., 85.48% and minimum pollen germination was noted in 70% Sucrose medium i.e., 56.06% (Fig. 2).

Estimation of Phytoremediation by macrophytes

The germination of *Thevetia peruviana* (Pers.) K. Schum pollen was totally inhibited in each of the control set, i.e., zero pollen germination was observed in all the three metals control experimental set culture medium, and for this reason it is not shown in any of the following graph.

For the experimental set of *Croton tiglium* Linn. the pollen of *Thevetia peruviana* (Pers.) K. Schum shows the differential germination inhibition. It is observed that pollen germination was not inhibited prominently in Cadmium (Cd) contaminated media and slightly inhibited in the media contaminated with Mercury (Hg). But germination was dominantly inhibited by the Zinc (Zn) (Fig. 3). From the result it might be said that *Croton tiglium* Linn. has the strong appetite for the Mercury and some lesser for the Cadmium but its appetite for the Zinc is not very strong. So it can be easily understood that *Croton tiglium* Linn. has effectively removed the Mercury but it is less effective in the removal of Zinc from contaminated water.

In the *Cyperus* Linn. set of experiment it appears that pollen germination has slight inhibition in the media contaminated with Mercury (Hg) and germination was moderately inhibited in the media contaminated with Cadmium (Cd). But the germination was distinctly inhibited in Zinc (Zn) (Fig. 3). The results claimed that *Cyperus* Linn. is strong potential accumulator of Mercury and its potential for Cadmium accumulation is some lesser and the least bioaccumulation of Zinc. So it is apparent that *Cyperus* Linn. has good bioremediation capacity for Mercury and cannot effectively bioremediate Zinc from the contaminated sites. Ab-Aziz *et al.* (2012), worked out the ability of *Cyperus kyllingia* Endl. to hydroponically treat digested industrial sludge contaminated with nine different heavy metals and found that it is efficient system at medium pH 6.87 ± 0.71 and EC 2.72 ± 1.85 µS/cm for heavy metal removal which includes Cadmium and Zinc.

In set of the *Alocasia* (Schott) G. Don it is found that pollen germination has less inhibitory effect of media contaminated with Mercury (Hg) and shows some more inhibition in the media containing Cadmium (Cd). But germination is effectively inhibited in the media contaminated with Zinc (Zn) (Fig. 3). From the above results it is estimated that *Alocasia* (Schott) G. Don has effectively extracted Mercury but its extraction potential for the Cadmium and Zinc is very low. So it can be stated that *Alocasia* (Schott) G. Don has successfully removed Mercury but for the removal of Cadmium and Zinc it remains unsuccessful.

For the *Sonchus oleraceus* Linn. treated germination medium it was observed that pollen germination was slightly inhibited in the media contaminated by both Mercury (Hg) and Cadmium (Cd) but the media contaminated with the Zinc (Zn) shows pronounced inhibition of germination (Fig. 3). The results revealed that *Sonchus oleraceus* Linn. is much effective plant in phytoremediation studies. It shows strong appetite for Cadmium and Mercury and less appetite for the Zinc. This it is obvious that *Sonchus oleraceus* Linn. is best suited species for the phytoremoval of Cadmium and Mercury but not Zinc.

For the experimental set of *Argemone mexicana* Linn. it appears that pollen germination was moderately inhibited in the media contaminated with the Cadmium (Cd) and has less inhibition in the Mercury (Hg) contaminated media but germination was more inhibited in the Zinc (Zn) contaminated media (Fig. 3).

A B C D E

Figure 1: Sampling Sites in MIDC effluent streams –
(A) *Alocasia* sp. (B) *Argemone mexicana* (C) *Croton teglium*
(D) *Cyperus* sp. (E) *Sonchus oleraceus*.

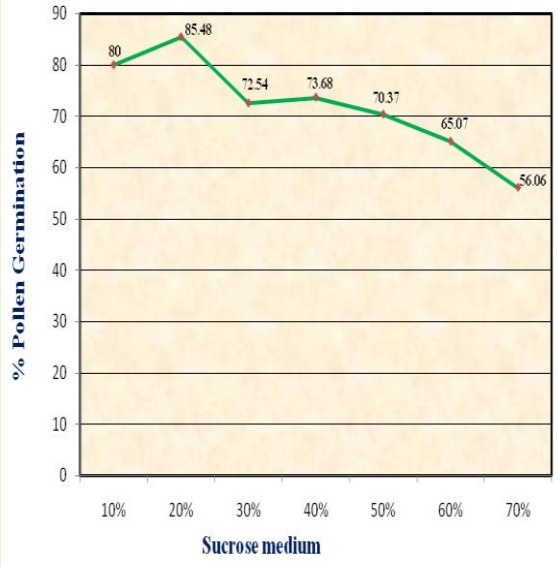

Fig. 2: *In vitro* Pollen Germination of *Thevetia peruviana* (Pers.) K. Schum.

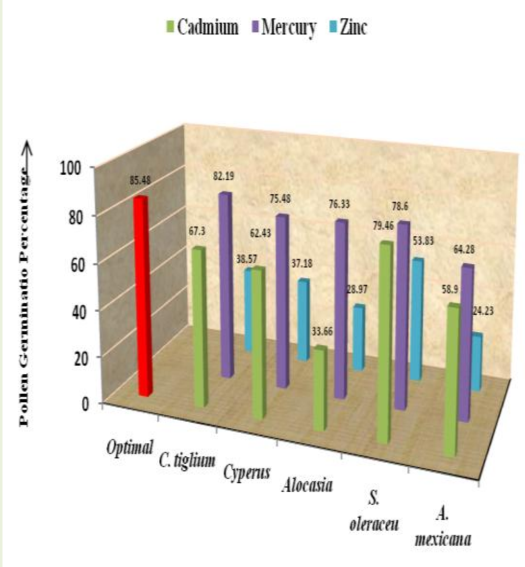

Fig. 3: *In Vitro* pollen germination in media contaminated with 50 mgL^{-1} heavy metal solution left after the 24 hrs treatment.

From the phytoremediation studies results on *Argemone mexicana* Linn*.* it appears that it shows more removal of Mercury than Cadmium and Zinc. This plant shows an efficient system for removal of Mercury but less efficient for the Zinc from the heavy metal contaminated bodies. Khairia and Al-Qahtani (2012) studied industrially polluted area which shows concentration of the eight heavy metals in the soil and seven native plant species as the heavy metal accumulator. Wherein *Argemone mexicana* Linn. is reportd to have the accumulation of heavy metals in plant organs.

Estimation of the toxic substances

Comparatively, although the five plants show the difference in the absorption of three different heavy metals solution but a common trend was observed in the pollen germination. From this discussion it is predicted that Zinc is more toxic or sensitive for these plants and Mercury is less.

CONCLUSION

Thus it can be concluded that macrophytes on MIDC effluent stream have undergone a selection pressure to develop a heavy metals resistivity.

After comparing the complete data the order of resistivity toward these three heavy metals studied is *Sonchus oleraceus* Linn. > *Croton tiglium* Linn. > *Cyperus* Linn. > *Argemone mexicana* Linn. > *Alocasia* (Schott) G. Don. Results also conclude that the order of sensitivity of heavy metals studied towards the five plants is Zinc > Cadmium > Mercury.

Unlike conventional technologies for the phytoremediation of heavy metal contaminated site which are not useful below the concentration level of 10 mg L^{-1}, these prescribed plants can be used as a remedy for heavy metals pollution. Besides having their role in phytoremediation they can also be utilized for their byproducts at contaminated site itself. According to the modern medicine and Ayurveda *Sonchus oleraceus* Linn. is medicinally important plant. *Argemone mexicana* Linn. also shows medicinal properties. *Croton tiglium* Linn. possesses medicinal as well as much nutritional value. *Cyperus* Linn. also shows medicinal values and can be used as food. Only some of the species of *Alocasia* (Schott) G. Don. are poisonous and some of the other can be used as food also. Thus the plant species sustaining proper growth and development under effluent sites are the perfect system for phytoremediation of heavy metals.

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